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A Dynamic Neural Circuit Model of Decision Confidence, Change of Mind and Multimodal Actions

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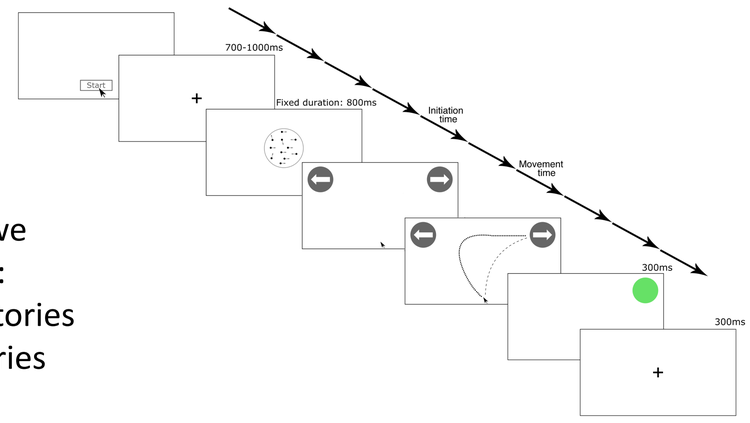
Introduction

Decision-making has been linked to the accumulation of evidence over time and is often accompanied with decision confidence, in which lower decision confidence more likely leads to change of mind. Various computational models of decision-making with confidence have been suggested. But they are either in abstract form or do not reconcile well with recent experimental data. Further, little is known regarding how decision confidence affects the movement of eye and hand when reporting choices.

This work proposes a new experimental task that reveals how gaze and hand movements reflect the underlying decision dynamics, and how decision confidence can affect these motor movements. A computational neural circuit model of decision-making is then proposed that can mechanistically account for decision confidence, change of mind, and multimodal action outputs.

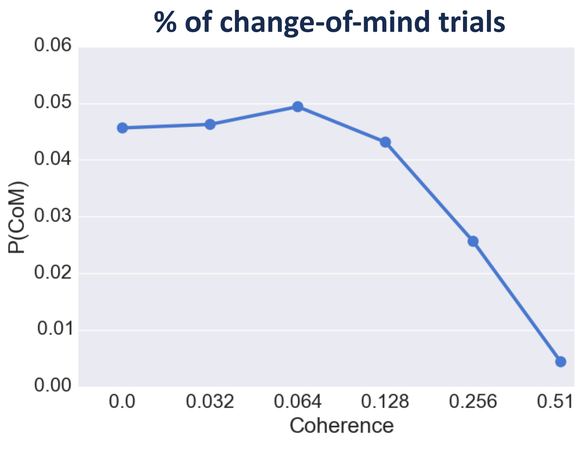
Experimental Task

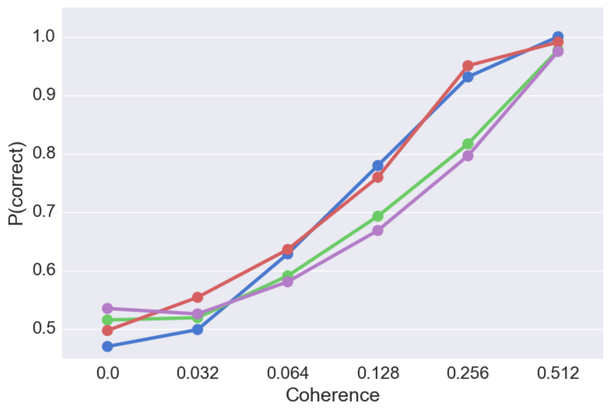
- Fixed duration (800 ms) random dot motion task paradigm
- 4 Adults, 400 trials per coherence level per subject.
- Subjects report their choices by moving the mouse cursor to left or right.
- Subjects were allowed to move their gaze when reporting their choices.

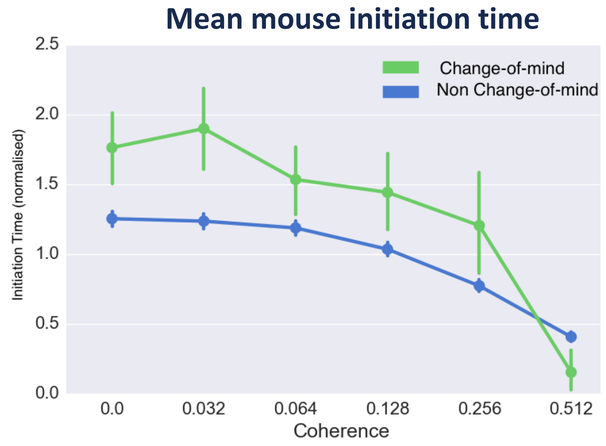


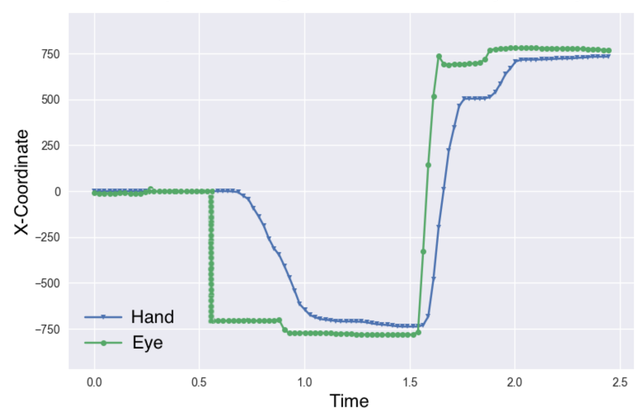
- During the experiment, we simultaneously recorded:
  - ✓ Mouse trajectories
  - ✓ Gaze trajectories

Experimental Results





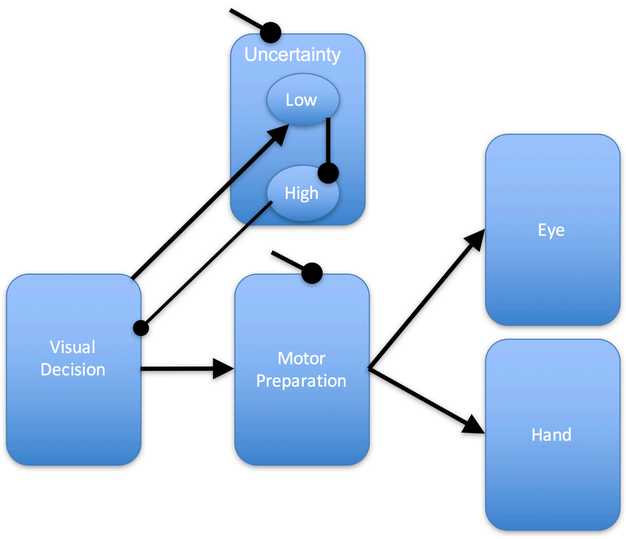




- 3.5% of trials are change-of-mind trials. Change-of-mind is more likely to occur in difficult trials (due to high uncertainty).
  - Initiation time in change-of-mind trials tends to be slower than in non-change-of-mind trials.
- A change-of-mind could occur early (mouse cursor is far from initial target) or late (mouse cursor is very close to initial target) within a trial.

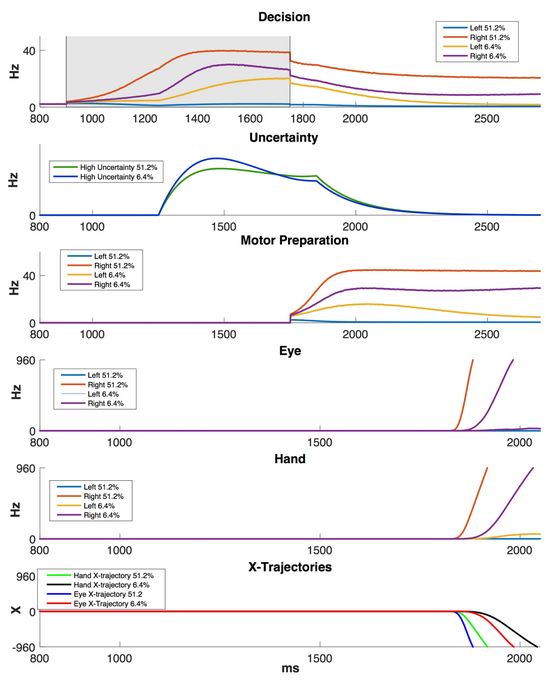
Neural Circuit Model

Model architecture

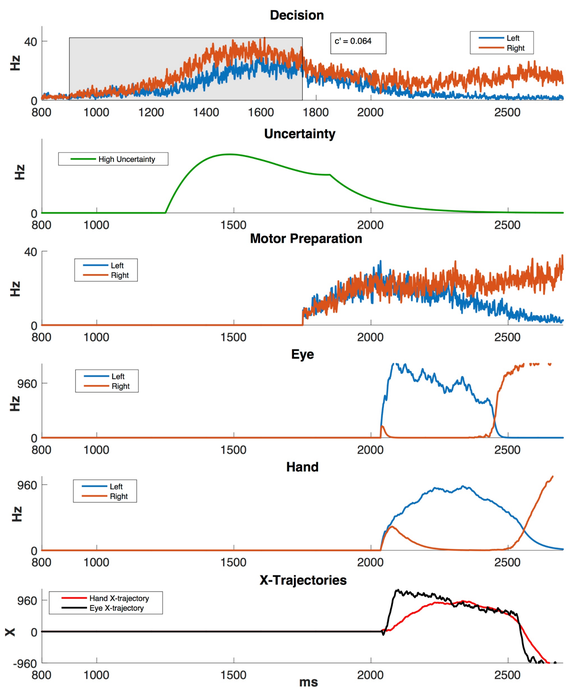


- Model accounts for decision confidence, change-of-mind and multi-modal action outputs.
- Modelled using nonlinear firing-rate type model.

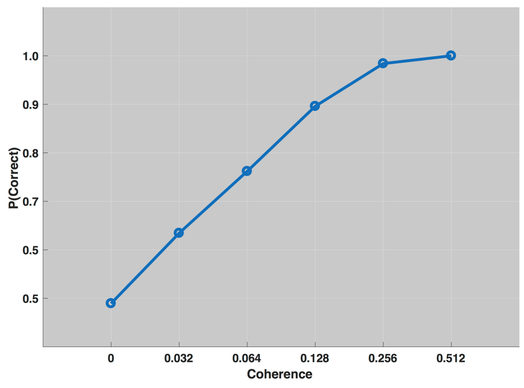
Trial-averaged non-change-of-mind trials



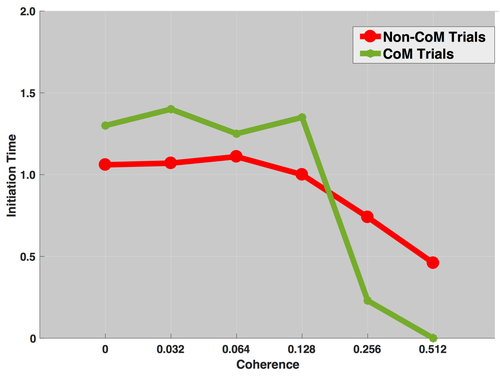
Sample change-of-mind trial



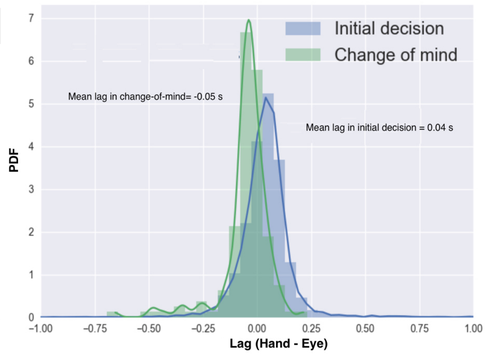
Model accuracy



Model initiation time



Experiment hand-eye lag



- Model readily provides a good fit for accuracy and initiation times.
- On average, our experiment shows that the initiation time of the eye movement is slower than that of the hand movement in the initial decision during change-of-mind trials.

Conclusion

- Our model provides a neurally plausible way to encode decision confidence for change of mind.
- Model accounts for initiation time; longer initiation time more likely leads to change-of-mind.
- Future work will optimise model and apply to other task paradigms.

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